Hence one might infer that the molal solubilities of the nitrates are probably essentially identical. The outcome gives strong experimental support for the hypothesis that isotopes are really inseparable by any such process as crystallization.

[1] *J. Amer. Chem. Soc., Easton, Pa.*, **29**, 1907, (1709).
[2] Richards and Wadsworth, These PROCEEDINGS, **2**, 1916, (505, 694).
[3] Richards and Wadsworth, *J. Amer. Chem. Soc. Easton, Pa.*, **38**, 1916, (2616).
[4] Baxter and Grover, *Ibid.*, **37**, 1915, (1058).

HYBRIDS OF ZEA TUNICATA AND ZEA RAMOSA

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Zea tunicata and *Zea ramosa* are the two most striking variations or mutations from normal maize. Though usually referred to as agricultural species they seem to deserve a place with the so-called species of Oenothera which have originated by mutation.

The chief characteristic of *Zea tunicata* is that the glumes of the female inflorescence, or ear, are developed so that each seed is entirely enclosed. Associated with this character is a less conspicuous lengthening of the glumes of the staminate inflorescence that results in a thickening of the tassel.

The origin of *Zea tunicata* is not known, but its occurrence in widely separated and isolated regions would indicate that it has originated independently more than once, presumably as a mutation from ordinary maize.

In hybrids with non-tunicate varieties the tunicate character behaves as a dominant, but in our experiments it has never been possible to secure a homozygous tunicate strain. Progenies resulting from the selfing of tunicate plants have always shown segregation into approximately three tunicate plants to one normal.

The tunicate plants in self-pollinated progenies are separable into two classes, one producing typical tunicate ears and thickened tassels like the parent plant, and the other with greatly enlarged tassels containing both staminate and pistillate flowers, and with the ear either aborted or bearing greatly enlarged and usually sterile spikelets. This last class represents approximately one-third of the tunicate plants. Although these plants produce what appears to be normal pollen in the terminal inflorescence the long glumes never open and the pollen is not shed, and we have not been successful in securing selfed seed of this form.

The ratios in which the different classes occur indicate that the class with the bisexual terminal inflorescence is the homozygous form, and that the ordinary tunicate plants represent the heterozygous form, a cross between the form with the bisexual inflorescence and the normal non-tunicate maize.

From experiments involving forty-three progenies derived from three distinct sources, it would appear that the ordinary type of tunicate ear represents an example of imperfect dominance as unfixable as the Andalusian fowls, but since other workers report the existence of pure tunicate strains it may be that other stocks behave differently.

The class with bisexual terminal inflorescence, which is here considered homozygous, will be referred to as full-tunicate and the ordinary tunicate type, which is looked upon as heterozygous, will be termed half-tunicate. The term tunicate or podded will be used as a general term including both of the above classes.

Zea ramosa or branched maize, discovered by Dr. W. B. Gernert[1] at the Illinois Agricultural Experiment Station, differs from normal maize in having the pistillate inflorescence or ear which is normally simple replaced by a compound inflorescence. There is also a less striking but equally significant change in the branching of the terminal inflorescence or tassel. In normal maize the terminal inflorescence bears a number of branches at its base. Above the uppermost branch the axis is continued into what is termed the central spike where the pairs of spikelets are borne directly on the axis of the inflorescence. There is thus in passing from the base to the tip of the tassel an abrupt transition from the uppermost branch to simple pairs of spikelets. In the *Zea ramosa* tassel the branches are much more numerous and gradually decrease in size from the base upward, the transition from branches to pairs of spikelets being imperceptibly gradual.

Unlike *Zea tunicata*, *Zea ramosa* is a recessive variation. The dominance of normal maize over this variation seems complete. It has not been possible in any way to distinguish between plants heterozygous for the ramosa character and normal maize. So far as observed, the character behaves as a simple Mendelian unit.

Both *Zea ramosa* and *Zea tunicata* are variations from normal maize toward the general type of grasses, and as such may be looked upon as reversions, since both cases involve a loss of a specialization that distinguishes maize from practically all other grasses.

Description of the Hybrid.—The cross between *Zea tunicata* and *Zea ramosa* was made in 1914. Nine first-generation plants of this cross were grown in 1915. Of these four were tunicate, and five normal,

indicating the heterozygous nature of the half-tunicate parent plant. The tunicate plants were all half-tunicate, and no trace of the ramosa characters could be seen.

Five self-pollinated first-generation ears were selected for planting in 1916. Three of these ears were tunicate and two normal. Four hundred and eight second-generation plants were matured in 1916—326 from the three tunicate ears, and 82 from the two non-tunicate ears of the first generation.

The progeny of the non-tunicate or normal F_1 plants showed segregation into normal and ramosa in the ratio of 3 to 1, the numbers being 65 normal and 17 ramosa. In none of these plants was there evidence of tunicate characters.

It was possible to classify the F_2 plants descended from the tunicate F_1 ears into (1) Normal, (2) Half-tunicate, (3) Full-tunicate, (4) Ramosa, and (5) Tunicate-ramosa. The last class comprised those plants in which both tunicate and ramosa characters could be recognized. When both the staminate and pistillate inflorescences were considered the classes were well marked.

In the tunicate-ramosa group there were many plants with an entirely new type of inflorescence. In these the branching habit, which suggests that of the ramosa parent, was developed to a grotesque extreme. As soon as branches formed these again branched. This division continued until the end of the growing season when the tissue was still in an embryonic condition and nothing resembling floral or foliar organs was formed. The result was a white succulent mass. This peculiar formation occurred in both lateral and terminal inflorescences, though it was much more common in the former, and in terminal inflorescences it was usually confined to the basal branches.

This type of inflorescence is similar, if not identical, with an abnormality discovered by Blaringhem in a strain of *Zea tunicata*[2] and termed by him 'cauliflower.'

It was found possible to account for the ratios by the assumption of relatively simple gametic composition. The tunicate character is represented by T and its recessive allelomorph, the normal condition, by T′. The recessive ramosa character is represented by R′ and its dominant allelomorph, the normal condition by R.

The observed numbers compared with the numbers expected in accordance with this gametic composition are given in the following table.

NUMBER EXPECTED OUT OF EACH 16	GAMETIC COMPOSITION	CHARACTERS OF PLANT	EXPECTED NUMBERS	OBSERVED NUMBER
1	T′ T′ R R	Normal	61.2	64
2	T′ T′ R R′	Normal		
2	T T′ R R	Half-tunicate	122.0	121
4	T T′ R R′	Half-tunicate		
1	T T R R	Full-tunicate	61.2	61
2	T T′ R R′	Full-tunicate		
1	T T R′ R′	Tunicate ramosa	61.2	64
2	T T′ R′ R′	Tunicate ramosa		
1	T′ T′ R′ R′	Ramosa	20.4	16
Total.....			326.0	326.0

In each of the parent varieties there is a deviation from normal maize in both the staminate and pistillate inflorescences. It is of interest, therefore, to determine so far as possible whether the changes in the two parts of the plant are due to a single gametic change, or whether they may be inherited separately.

With this point in mind the plants were classified with respect to their tassels, and ears, independently, with the following results:

The normal plants were all normal in both tassel and ear.

The distinction between half- and full-tunicate is somewhat arbitrary, but with one exception all the 121 plants classified as half-tunicate by their tassels also had ears classed as half-tunicate. That the distinction is genetic and not merely physiological is indicated by the absence of any sensible correlation between the length of the staminate and pistillate glumes on the individuals inside the half-tunicate group.

Of the 53 plants classed as full-tunicate by their tassels, all but two had either full-tunicate ears, or none at all, and the two exceptions had pistillate glumes only slightly below 45 mm., the minimum length set for the glumes of full-tunicate ears. There is then almost a perfect correlation between the type of tassel and ear, but here again there is no correlation inside the group. That is, long glumes in the tassel were not correlated with long glumes on the ear. Even the extreme form of full-tunicate plants that produced no ears did not differ, with respect to the length of the staminate glumes, from the plants bearing ears.

When both tunicate and ramosa characters were present in the ears, the tassels were always ramosa but the tunicate characters were not always apparent in the tassel.

Conversely, the 53 plants with ramosa tassels all exhibited ramosa characters in the ears, either pure or combined with the tunicate character.

Perhaps the most interesting class of plants were those with cauli-

flower inflorescences. This peculiar type of pistillate inflorescence seems definitely confined to the class of plants combining the tunicate and ramosa characters.

The cauliflower character, which in itself would seem more nearly related to ramosa than to tunicate, is somewhat more definitely associated with the ramosa than with the tunicate character of the tassels.

There were 22 plants with pure cauliflower ears. Twenty of these had tassels in which both tunicate and ramosa characters were obvious. The other two were classed as having ramosa tassels. Of the 13 plants with partial cauliflower ears 11 had ramosa tassels in which no tunicate characters were observed, and two showed evidence of both tunicate and ramosa in their tassels.

If the second-generation plants are examined for each of the parental types separately, there is seen to have been a simple 1 to 3 segregation in both instances. One-fourth of the total number of plants are ramosa and three-fourths non-ramosa (observed 79 to 247, expected 81.5 to 244.5). One-fourth are non-tunicate and three-fourths tunicate (observed 80 to 246, expected 81.5 to 244.5). The distinction between half- and full-tunicate could not be made when these characters were combined with the ramosa character. The various combinations of parental characters, occurring as they do in the normal di-hybrid ratios, show that the tunicate and ramosa characters are not genetically correlated.

The extended publication will appear in the *Journal of Agricultural Research.*

[1] Gernert, W. B., A new subspecies of zea mays L., *Amer. Nat., Lancaster, Pa.*, 1912, 46 (616-622).

[2] Blaringhem, Louis, *Mutation et traumatismes*, Paris, 1907, (121–122).

DISTRIBUTION OF GALL MIDGES

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The intimate relation existing between many species of these tiny, fragile flies and their food plants and the relatively limited migratory ability of either adults (owing to their weak powers of flight), or the larvae (due to their apodous or nearly apodous condition), led to a study of the distribution of these highly variable forms. The immensity of the complex may be appreciated by remembering that approximately three hundred genera and probably nearly three thousand species are known—the largest about 6 mm. in length and the smallest less than 0.5 mm. long. Some live in decaying or dead organic matter, others